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SPECIAL FEATURE: WEST NILE VIRUS: PUBLIC HEALTH ISSUES RAISED BY AN EMERGING ILLNESS

The Challenges of Emerging Illness in Urban Environments: An Overview

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ABSTRACT *The New York City West Nile outbreak is an important case study for examining several medical and public health issues raised by the specter of emerging illnesses in urban areas. Five specific issues are addressed in this issue of the* Journal of Urban Health*: ecosystem health, vector (e.g., mosquito) control, risk communication, public health infrastructure, and parallels between this outbreak and bioterrorism.*

The outbreak of West Nile virus illness in New York in the summer of 1999 was a major public health event. The appearance of a potentially fatal viral illness never before seen on this continent drew wide scientific and public attention. The response was vigorous and involved scientists and public officials at local, state, and national levels.[1–3] While political leaders assured the public that all appropriate actions were being taken, citizens were simultaneously concerned about both a new mosquito-borne illness and the use of pesticides.

On December 11 and 12, 2000, the Center for Children's Health and the Environment of the Mount Sinai School of Medicine and the New York Academy of Medicine convened a conference, "Challenges of Emerging Illness in Urban Environments." The purpose of the conference was to review the outbreak of West Nile virus in New York City and to examine the broader medical and public health issues raised by emerging illnesses in urban areas. The response to West Nile virus in New York City was used as a case study to illuminate the conference discussion. The conference focused on five specific issues: ecosystem health, vector control, risk communication, public health infrastructure, and bioterrorism parallels.

This issue of the *Journal of Urban Health* includes papers on topics presented at the conference, as well as a set of policy recommendations arising from the conference discussions. We offer here a brief introduction to the five conference topics.

WEST NILE VIRUS: A CASE STUDY

West Nile virus is a member of the Japanese encephalitis complex of flaviviruses and is antigenically related to St. Louis encephalitis. In cities, the virus is carried

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by *Culex pipiens* mosquitoes and domestic birds. The cycle of transmission in the countryside involves wetland birds and bird-loving mosquitoes.[4] Recent surveillance has demonstrated the presence of West Nile virus in several mosquito species in addition to *Culex pipiens*.

Knowledge of the replication cycle of West Nile virus is crucial to the development of plans to prevent and combat new epidemics.[5,6] The virus incubates in mosquitoes for 10 days to 2 weeks, after which it travels to the insect's salivary glands. Infected mosquitoes transmit West Nile virus through blood feeding, by which the virus injected into the human or animal multiplies and can cause illness.[1,6,7]

The clinical features of West Nile virus are varied. Most people infected by West Nile virus are asymptomatic or may experience mild illness such as fever, headache, and body aches before fully recovering. Some persons also develop a mild rash or swollen lymph glands. At its most serious, it can cause permanent neurological damage and can be fatal; however, less than 1% of those infected develop severe neurologic disease.[5] The elderly and the immunocompromised are particularly at risk for developing West Nile encephalitis. Symptoms of encephalitis (inflammation of the brain) include the rapid onset of severe headache, high fever, stiff neck, confusion, loss of consciousness (coma), and muscle weakness.[1,4]

The 1999 outbreak in New York City was the first documentation of West Nile virus in the Western Hemisphere. Previous outbreaks have occurred in other countries. In Israel, where West Nile virus is endemic, over 120 people had symptoms as of September 2000 and 8 had died.[8] On August 23, 1999, an infectious disease physician from Queens, New York, reported 2 human encephalitis cases to the New York City Department of Health. After investigation, the New York City Department of Health initially identified a cluster of 6 cases. One week later, active surveillance by the health department revealed 2 more cases in a 2-square-mile area. On September 3, active surveillance was expanded to Westchester and Nassau counties. Prior to and during the outbreak, local health officials observed an increase in fatalities among New York City metropolitan area birds, especially crows. In early September, exotic birds (flamingoes, herons, and bald eagles) died at the Bronx Zoo, and necropsy demonstrated encephalitis and myocarditis. The initial diagnosis was St. Louis encephalitis. The illness was later identified by the US Centers for Disease Control and Prevention (CDC) as West Nile encephalitis caused by the West Nile virus.[9]

From July to September 1999, 62 cases of West Nile encephalitis with 7 deaths were reported in the New York City metropolitan area.[1] A serosurvey conducted in Queens following the epidemic estimated that at least 1,900 residents of Queens were unknowingly infected with the virus.[10] Evidence has accumulated to estimate the range of the virus itself. West Nile virus was found in tissues of dead horses on Long Island, and infected mosquitoes and birds were discovered in Connecticut and New Jersey. A variety of control measures was used, including surveillance of mosquito breeding sites, larvicide application, and adult mosquito control. The virus was determined to have spread 30 miles from its epicenter in Queens during 1999.[2] When the temperature fell during fall 1999, the number of new cases subsided.

In the summer of 2000, West Nile virus reappeared in New York City, but with some surprising differences from the 1999 outbreak. The zone of transmission expanded to include Upstate New York, New Jersey, Massachusetts, Rhode Island, New Hampshire, Connecticut, and Maryland. More than 2,000 birds and dozens of animals, including raccoons, bats, and rabbits, were found to be seropositive for

West Nile virus.[2] The wider geographic range of the virus and the increased number of animals infected would suggest a greater possibility for human infection. Yet, the rates of human infection and mortality in 2000 were lower than in 1999. In 2000, there were 18 confirmed human cases of illness caused by West Nile virus, with 4 in New Jersey and 14 in New York.[11] One individual, an 82-year-old man in New Jersey, died of the virus.[12] This broadening of the geographic range from 1999 to 2000 will be important to consider as the season for breeding of mosquitoes starts in 2001.

In this issue, Dr. James Miller, Coordinator of Arthropod-Borne Disease Surveillance and Control for the New York City Department of Health, notes that the West Nile outbreaks in 1999 and 2000 required the implementation of mosquito control efforts. He notes that these efforts included public and professional education, laboratory testing, case reporting, mapping of mosquito breeding sites, application of larvicide, and adult mosquito control. With the 2001 season upon us, Dr. Miller concludes that a sustainable plan for mosquito-borne disease surveillance and control is needed in New York City to prevent human illness.

ECOSYSTEM HEALTH

Ecosystem health is a new interdisciplinary scientific field that investigates the relationship among human activities, environmental change, and public health.[13] The West Nile virus epidemic provides an example of how ecosystem health science can contribute to our understanding of the emergence of infectious diseases. For example, increased human migration may facilitate the spread of viruses to new areas. Before the 1999 New York City epidemic, West Nile virus had never been identified in the Western Hemisphere, having previously been confined to Africa, southwest Asia, eastern Europe, and the Middle East. It is not known how the virus entered North America, but genetic analysis has shown the New York City virus, isolated in specimens, is virtually identical to the virus circulating in Israel since 1997.[14]

Ecosystem health science also provides insight into potential changes in vector populations in relation to climate change. Global warming may lead to floods or drought conditions not normally expected in specific geographic locations. Heavy rains, flooding, irrigation, and increasing temperatures may all contribute to the formation of new ecological niches for disease-carrying mosquitoes.[4] The weather pattern favoring bird-mosquito-human diseases—warm winters followed by summer droughts—may have also contributed to the epidemic. Predators of mosquitoes decline with drought, while birds may congregate around shrinking water sites, encouraging the amplification of the virus in vector populations. In addition, "generalist birds," particularly crows in the case of West Nile virus, may also play a role in an outbreak. These birds may be more tolerant of pathogens than less wide-ranging species and may hasten the spread of the virus.

In this issue, Dr. Paul Epstein, Associate Director of the Center for Health and the Global Environment at Harvard Medical School, suggests that global warming and other climate alterations induced by global warming may increase the incidence and widen the distribution of many serious medical disorders, including emerging infectious diseases. He concludes with recommendations for restabilizing the climate by limiting human activities that contribute to global warming or that exacerbate its effects.

VECTOR CONTROL

In 1999, after identifying the cause of the West Nile outbreak, public health officials worked to minimize the risk of human exposure to the virus. The extent of West Nile virus in mosquitoes was unknown, and officials believed that a vigorous vector control response was required to prevent a widening epidemic. The response included the widespread application of pesticides.[9] Public concerns about the vector control program included the method of pesticide application and potential pesticide health risks to the human population.[15–17]

The recent history of malaria control provides an example of the current debate over the balance of the risks of pesticide use and the risk of disease. Because of its environmental and human health risks, the pesticide DDT is not used in the United States. But, DDT still has important use in malaria control in other parts of the world. Some countries in South America stopped using DDT in the 1990s, only to see malaria rates increase. Other malaria control approaches, such as public education, use of mosquito nets, and local insecticide application to dwellings, are important, but have not been completely effective.

Ecuador, the only country to increase its DDT use in the last decade, has seen a decrease in malaria rates since 1993. In addition, DDT is more economical than other methods of control. It costs Ecuador only $1.44 to spray one house for 1 year with DDT. In contrast, malathion, which was used in New York City to help control mosquitoes during the West Nile virus outbreak, is five times as expensive as DDT.[18] The World Health Organization's Roll Back Malaria Campaign in Vietnam from 1990 to 1997 produced a substantial decrease in malaria mortality through drugs and chemically treated bed nets, while also dramatically reducing the use of DDT.[19] Human health, environmental factors, budgetary constraints, and public attitudes and behaviors all need to be considered in formulating a public health policy for vector control. The use of DDT for malaria control has been allowed in the recently concluded international POPs (persistent organic pollutants) treaty after several years of debate of the relative risks of malaria and DDT exposure.

In this issue, Audrey Thier, Pesticides Project Director of Environmental Advocates, identifies the complex issues that must be balanced by public health officials in the decision to use pesticides. She emphasizes the importance of having a formal decision-making framework for assessing the appropriate response to new pathogens.

RISK COMMUNICATION

Risk communication can be defined as the exchange of information among interested parties about the nature, magnitude, significance, or control of risk. Effective risk communication is based on an in-depth understanding of the knowledge, attitudes, and perceptions of the target audience. Risk communication requires knowledge, preparation, training, and practice.[20–23] The goal of risk communication is to establish the trust and credibility required for acceptance of a message by a target audience.

Effective communication with health care professionals and the public about the possible risks of disease is essential to managing a disease outbreak. Health care providers are generally the first to observe and report unusual illnesses. Communication with these providers is the core of a surveillance and tracking system. In the

West Nile virus event, the first report of human encephalitis cases to the New York City Department of Health came from an infectious disease physician. Public education about disease, particularly about modes of transmission and means of reducing risk of exposure, is a critical component of a program of prevention and control.[5] In the case of West Nile virus, prevention efforts, such as eliminating mosquito-breeding sites around homes and methods for reducing pesticide exposure, need to be communicated clearly to the public to reduce the human risk of exposure to the virus and to pesticides.

In this issue, Dr. Vincent Covello and colleagues from the Center for Risk Communication summarize the principles of sound risk communication and assert that these principles can be effective. They identify planning, preparation, and practice as the key components of successful risk communication.

PUBLIC HEALTH INFRASTRUCTURE

Many of the problems that occurred during the response to the virus in New York may be attributed to the new and unknown nature of West Nile virus itself. The New York City Department of Health has prepared and published a comprehensive plan for surveillance and control.[24] The plan relies on a core, year-round staff for human and animal surveillance, research, evaluation, and administration and a seasonal workforce for vector surveillance and control activities. Contractors are hired to assist in the development of public education campaigns. Contractors are also hired for the application of larvicides and, if necessary, the spraying of pesticides to reduce the adult mosquito population. The plan requires increased communication and coordination among city, state, and federal agencies, along with community and professional organizations.

Tracking and surveillance practices tend to vary within the national public health infrastructure, which can lead to significant variations in reporting of cases and control of disease. For example, West Nile virus is studied and managed by a variety of large agencies. The Centers for Disease Control and Prevention monitors human cases, while the Environmental Protection Agency monitors pesticide use; other federal agencies (e.g., the Department of the Interior) monitor bird and animal behavior and disease. No single agency or site aggregates all the current data into a central repository.[2] A more sophisticated national system of tracking disease and surveillance is clearly necessary.

James O'Hara, Executive Director of Health-Track, makes the important point that, while the public health response to West Nile was adequate, the response required an extraordinary one-time application of governmental resources. He argues that the West Nile incident provides a cogent illustration of the weaknesses in the surveillance and tracking of not only West Nile virus, but also all diseases in this country.

BIOTERRORISM PARALLELS

Many components of the public health infrastructure, including surveillance, tracking, and response, are relevant to both bioterrorism and emerging illness. In October 1999, the National Health Policy Forum (NHPF) convened a conference, "Preparing for a Bioterrorist Incident: Linking the Public Health and Medical Communities." The report from the conference stated:

> According to the experts, although the West Nile incident was tiny, relative to what is contemplated in a weapons-of-mass-destruction scenario, it completely overwhelmed the public health capacity in New York City, a city considered by many as a model for bioterrorism preparedness.[25(p2)]

Extrapolating from the response to New York City's 1999 West Nile virus epidemic, it is clear that the United States is not currently prepared for a large-scale bioterrorist event. According to the National Health Policy Forum, surveillance, physician, and laboratory facilities capable of identifying rare and exotic agents, vaccine and pharmaceutical supplies, information sharing, and training are currently inadequate. During a potential event, the chain of command is unclear, and treatment capabilities, prophylaxis, disaster management, and health care facility capacity are insufficient. Methods and resources for disposing of the deceased and meeting the mental health needs of civilians following an incident are lacking. Compounding the problem is a lack of coordination and a communication gap between the medical and public health communities in preparing for bioterrorism. All of these inadequacies must be addressed within the public health infrastructure to prevent illness and death that would result from biological terrorism.[26] As with emerging infectious diseases, early detection and control of a biological attack will depend on a strong and flexible public health system at the local, state, and federal levels.

Dr. Tara O'Toole, Deputy Director of the Center for Civilian Biodefense Studies at Johns Hopkins University, argues that American society is vulnerable to attacks by biological weapons. In this issue, she discusses the medical and public health consequences of biological weapons and the national security implications of the current revolution in biotechnology and genomics. She argues further that new resources and infrastructure expansion are necessary and will benefit both traditional public health and bioterrorism response agendas.

CONFERENCE RECOMMENDATIONS

The conference, "Challenges of Emerging Illness in Urban Environments," was conducted in five sequential sessions, each led by a moderator, with a panel of presentations relevant to the session topic. Each panel of speakers met in a breakout session. The goal of these sessions was to craft a set of topical policy recommendations. The recommendations emphasize the importance of collaboration across disciplines, increasing communication among local, state, and federal agencies, and increasing funding for public health research and function to fill in the many gaps in knowledge of emerging illnesses. Specific recommendations include those presented below.

Ecosystem Health

- Form interdisciplinary advisory groups with experts from fields of relevant study, including wildlife experts, veterinarians, ecologists, public health professionals, and meteorologists.
- Advocate for the integration into public health agencies of experts from various disciplines.
- Work with water and sanitation workers to clean up drainage sites to reduce mosquito-breeding sites.
- Study environmental change and use long-term projections of climate change to determine the impact of ecosystem change on human health.

Vector Control

- Stress the use of preventive measures, such as eliminating standing water, to reduce mosquito-breeding sites and mosquito surveillance. Pesticide use against adult mosquitoes should be a last resort.
- Use integrated pest management (IPM). IPM incorporates the use of preventive measures and the minimal use of least-toxic pesticides.
- Examine the effectiveness and optimal conditions for pesticide use and plan before using a pesticide as a response in an outbreak.
- Disseminate useful and appropriate information about pesticides in an appropriate fashion to all affected communities prior to spraying.

Risk Communication

- Deliver complete and accurate information to the public.
- Identify all stakeholders and allow them to participate in the risk communication process. Allow the public to voice their concerns and professionals from across disciplines to exchange knowledge.
- Identify public risk perception and use it to target the message. Let audiences know they have personal control or personal choice in the situation so they may be more apt to engage in the conversation and listen to the message.
- Use a credible spokesperson or organization to communicate the message to promote for public acceptance.
- Implement "dress rehearsals" or "scenario planning" when possible. Determine which risk communication steps would be effective in delivering the educational message in high-concern, sensitive, or controversial situations.

Public Health Infrastructure

- Strengthen the overall public health infrastructure. Particular attention should be given to small local health departments, which may lack funding, emergency planning capacity, and human resources.
- Create an adequate reporting and tracking system for both disease occurrence and environmental exposures, including pesticide use. Hospitals can be used to track disease. Local health departments should be capable of collecting and analyzing the data.
- Increase state and local laboratory capacities to handle large volumes of material. Have the capacity to conduct appropriate tests and have the ability to perform biomonitoring.
- Develop a communication system and linked action plan connecting local, state, and federal agencies and including international organizations to facilitate the flow of information.
- Train public health professionals to be able to respond to public concerns. Hot lines should be staffed by educated professionals who can provide accurate information and referrals. Provisions for monitoring exposure to vector control agents, follow-up, and registry should be implemented.
- Develop expert training for health care professionals in the community. Increase programs that specifically focus training for people to be employed at state and local public health departments. Provide adequate training for environmental experts.
- Use local community groups to help advocate for increased funding from the government. Raise public consciousness by using the media so that the public can also help support advocacy efforts.

CONCLUSION

The West Nile virus outbreak in New York was successfully managed by the determined and sustained efforts of public officials at the local, state, and national levels. Planning and resources, however, were barely adequate to many of the response tasks. The articles in this series review in detail the many valuable lessons learned from this public health event.

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